NASA Innovative Advanced Concepts

APIS (Asteroid Provided In-Situ Supplies): 100MT Of Water from a Single Falcon 9 (APIS)

Completed Technology Project (2015 - 2016)

Project Introduction

Asteroid Provided In-Situ Supplies (Apis) is a breakthrough architecture and mission concept using thin-film structures and anidolic optics to provide highly-concentrated solar power for asteroid ISRU and solar thermal propulsion. This new architecture includes a powerful new ISRU method we call 'Optical Mining'. Our anidolic optical mining technique is orders of magnitude faster, lighter, and cheaper than electrically-based ISRU process and avoids robotic augers, harpoons, and asteroid landing systems that will not work due to the dust-rich, micro-g, friable, and heterogeneous nature of asteroids.

Anticipated Benefits

The proposed study will show how NASA can lead us to becoming a space-fairing civilization with human activities in space \xd2living off the land\xd3 in a self-sustaining way. This will inspire the public and show the relevance of NASA to the private sector economy in ways other exploration architectures cannot. In addition, this study will further the general understanding and technology of non-imaging optics, which is emerging as an important branch of alternative energy technology. Non-NASA applications of inflatable structures and solar thermal propulsion will benefit commercial space ventures, communications satellites, and defense. The modeling and simulation of asteroid composition, structure, distribution, and discoverability will have direct benefit to the planetary science community, to other on-going NASA missions studies, and to planetary protection work. Modeling the geophysics of optical mining will be useful and applicable to certain terrestrial mining technologies. Apis will \xd2Change the Possible\xd3 so we can mine the asteroids and enable space industrialization.

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

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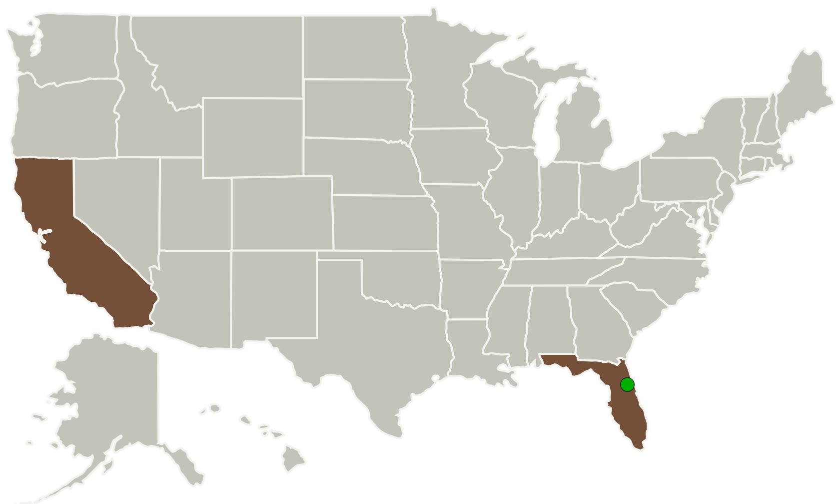
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Integrated Concurrent System Associates, Inc.	Supporting Organization	Industry	
Kennedy Space Center(KSC)	Supporting Organization	NASA Center	Kennedy Space Center, Florida

Primary U.S. Work Locations	
California	Florida

Project Transitions

July 2015: Project Start

Project Management

Program Director:

Jason E Derleth

Program Manager:

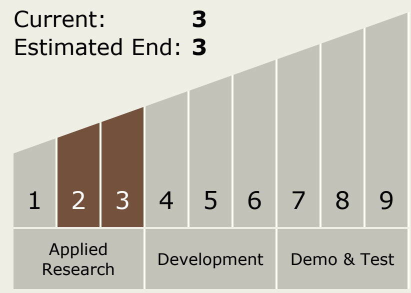
Eric A Eberly

Principal Investigator:

Joel Sercel

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX07 Exploration Destination Systems
  - └ TX07.1 In-Situ Resource Utilization
    - └ TX07.1.2 Resource Acquisition, Isolation, and Preparation

Target Destination

Outside the Solar System

June 2016: Closed out

Closeout Summary: The vision of using asteroids as the stepping stones to the solar system has been shared by many for over a century beginning with Konstantin Tsiolkovsky first postulating the idea in 1903. Other space technology pioneers w ho considered practical applications of asteroid resources include Robert Goddard in 1918 and Gerard K. O'Neill in the 1970 s. In the 1990s the well regarded planetary scientist John Lewis proposed asteroids as the source of in-space propellant for space operations. More recently, privately backed startup companies have worked on small prospecting spacecraft with an eye toward someday returning precious metals to the Earth. To move beyond being just a vision, the study of asteroid reso urce utilization needs a clear and technically rigorous plan for how to cost effectively extract and use asteroid resources as an economically viable approach to supporting space operations. This Phase I NIAC project provides that needed plan. The ApisTM architecture is a clear and technically viable way to build an in-space transportation network that can reduce the co st of space operations so NASA can accomplish its vision of human exploration of space within a politically realistic budget. To do this, the Apis architecture comprises several elements including the Honey BeeTM asteroid mining vehicle, the Worke r BeeTM reusable deep space tug, and the HiveTM consumables depot in lunar distant retrograde orbit (LDRO). Together, th ese systems form a cost-effective reusable cis-lunar transportation network supplied by asteroid resources to eliminate the need for launching large quantities of consumables to support human exploration of deep space beyond LEO. Lightweight, t hin film solar concentrators, structures, and optical systems are a key features of all elements of the Apis architecture whic h relies on raw solar thermal power in place of electrical power for all materials processing and propulsion functions. The wo rk described in this report has proven the feasibility of three critical technologies: Optical MiningTM; the OmnivoreTM solar t hermal engine; and technical means to determine the quantity and accessibility of asteroid resources that support cis-lunar operations. In addition we have performed conceptual level vehicle design and performance analysis showing the viability of the ApisTM approach. Optical MiningTM is a breakthrough method of asteroid ISRU which avoids the need for costly and co mplex electric power systems or intricate and massive robotic digging equipment. Instead, in Optical MiningTM asteroid mat erial is loosely encapsulated in tough, thinfilm bags with ports that permit the introduction of telescopic optics to deliver hig hly concentrated solar thermal power to the surface of the asteroid. We have experimentally demonstrated that such radiati on can excavate rock and breakup asteroid material though spalling. The passive storage of the resulting evolved gases as i ce in thin film bags is enabled through the use of second surface mirror coatings on thin film enclosures. The OmnivoreTM s olar thermal rocket is a breakthrough propulsion technology invented under this Phase I NIAC effort. Not just a solar therm al rocket, the OmnivoreTM thruster is a fundamentally new propulsion capability that will be able to use raw, unprocessed, dirty, volatile products from the Optical MiningTM process directly as propellant to deliver approximately 100 times the thru st of a correspondingly massive solar electric propulsion system but without the need for expensive propellant to be launch ed into space from the Earth.

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html